DEFENSE THREAT REDUCTION AGENCY
SBIR FY07.1 Proposal Submission

The mission of the Defense Threat Reduction Agency (DTRA) is to safeguard the United States and its allies from weapons of mass destruction (chemical, biological, radiological, nuclear and high-yield explosives) by providing capabilities to reduce, eliminate and counter the threat and mitigate its effects. This mission includes research and development activities organized into chemical/biological, nuclear, WMD counter-force, and systems engineering technology portfolios. From these activities, DTRA administers two SBIR programs. One is affiliated with the Chemical-Biological Defense Program and appears as a separate component under this solicitation. The other is drawn from the nuclear, WMD counter-force, and systems engineering portfolios and is described herein. Communications for this program should be directed to:

Defense Threat Reduction Agency
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Use of e-mail is encouraged.

The DTRA SBIR program complements the agency's principal technology programs to detect/locate/track WMD; interdict or neutralize adversary WMD capabilities; protect against and restore following WMD use; attribute parties responsible for WMD attacks; and provide situational awareness and decision support to key leaders. SBIR topics reflect the current strategic priorities where small businesses are believed to have capabilities to address challenging technical issues. DTRA supports efforts to advance manufacturing technology through SBIR, where the challenges of such technology are inherent to technical issues of interest to the agency.

PROPOSAL PREPARATION AND SUBMISSION

Proposals (consisting of coversheets, technical proposal, cost proposal, and company commercialization report) will be accepted only by electronic submission at http://www.dodsbir.net/submission/. Paragraph 3.0 of the solicitation (http://www.dodsbir.net/solicitation/) provides the proposal preparation instructions. Consideration is limited to those proposals that do not exceed $100,000 and six months of performance. The period of performance may be extended up to six additional months following award, but such extensions may delay consideration for Phase II proposal invitation. Proposals may define and address a subset of the overall topic scope. Proposals applicable to more than one DTRA topic must be submitted under each topic.

PROPOSAL REVIEW

During the proposal review process employees from BRTRC, Inc. and Northrop Grumman Information Technology (NGIT) will provide administrative support for proposal handling and will have access to proposal information on an administrative basis only. Organizational conflict of interest provisions apply to these entities and their contracts include specifications for non-disclosure of proprietary information. All proposers to DTRA topics consent to the disclosure of their information to BRTRC and NGIT employees under these conditions.

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DTRA will evaluate Phase I proposals using the criteria specified in paragraph 4.2 of the solicitation with technical merit being most important, followed by principal investigator qualifications, and commercialization potential. Topic Points of Contact (TPOC) lead the evaluation of all proposals submitted in their topics.

SELECTION DECISION AND NOTIFICATION

DTRA has a single source selection authority (SSA) for all proposals received under one solicitation. The SSA either selects or rejects Phase I proposals based upon the strengths and weaknesses identified in proposal review plus other considerations including limitation of funds and balanced investment across all the DTRA topics in the solicitation. Balanced investment includes the degree to which offers support a manufacturing technology challenge. To balance investment across topics, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

Following the SSA decision, the contracting officer will release notification e-mails through DTRA's SBIR evaluation system for each accepted or rejected offer. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their proposal. Debriefings would be viewable at https:\\www.dtrasbir.net\debriefing\ and require password access. Debriefings are provided to help improve the offeror's potential response to future solicitations. Debriefings do not represent an opportunity to revise or rebut the SSA decision.

For selected offers, DTRA will initiate contracting actions which, if successfully completed, will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a 6-month period of performance that may be extended, as previously discussed. DTRA may complete Phase I awards without additional negotiations by the Contracting Officer or opportunity for revision for proposals that are reasonable and complete.

DTRA's projected funding levels support a steady state of 14 or 15 Phase I awards annually. Actual number of awards may vary.

CONTINUATION TO PHASE II

Only Phase II proposals provided in response to a written invitation from a DTRA contracting officer will be evaluated. DTRA invitations are issued based on the degree to which the offeror successfully proved feasibility of the concept in Phase I, program balance, and possible duplication of other research. Phase II invitations are issued when the majority of Phase I contracts from the preceding solicitation are complete, typically early spring. Phase I efforts which were delayed in award or extended after award will be considered for invitation the following year.

DTRA's projected funding levels support a steady state of 7 new Phase II awards annually to meet an objective of continuing approximately 50 percent of Phase I efforts to Phase II. Actual number of awards may vary.

OTHER CONSIDERATIONS

DTRA does not utilize a Phase II Enhancement process. While funds have not specifically been set aside for bridge funding between Phase I and Phase II, DTRA does not preclude FAST TRACK Phase II awards, and the potential offeror is advised to read carefully the conditions set out in this solicitation.

Notice of award will appear first in the Agency Web site at http://www.dtra.mil. Unsuccessful offerors may receive debriefing upon written request only. E-mail correspondence is considered to be written correspondence for this purpose and is encouraged.

DTRA SBIR 07.1 Topic Index

DTRA SBIR 07.1 Topic Descriptions

DTRA07-001 TITLE: Fast Neutron and Gamma Detectors

TECHNOLOGY AREAS: Sensors, Nuclear Technology

OBJECTIVE: To develop a radiation detection system capable of detecting and discriminating between fast neutrons (> 1 eV) and gamma rays for use in the active and passive detection of special nuclear materials SNM).

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) seeks innovative methods for detecting and discriminating between neutrons with energies > 1 eV and gamma radiation. The conventional method for detecting neutron radiation involves moderating neutrons to thermal energies so they can be absorbed by detector materials that is are most sensitive to thermal neutrons. However, during this moderating process, much of the lifetime information of the individual neutrons is lost; including energy and directional information. Such information can be critical in identifying the source of neutron radiation. The detector developed through this research must be able to discriminate between neutron and gamma interactions in the detector. Additionally, the detector must be able to operate within 1-micro second following a 3-micro second pulse of 1010 photons, which may be regularly repeated at up to 1-KHz.

PHASE I: Develop design(s) for fast neutron (> 1 eV) and/or gamma-ray detection systems that offer both the potential of achieving the above requirement significant improvement over present detector technology. Demonstrate experimentally that a detector design is feasible and that achieving the refresh cycle in the objective is theoretically feasible.

PHASE II: Develop a prototype device and demonstrate it in a laboratory environment. A comparison to the above objective would result.

PHASE III DUAL USE APPLICATIONS: Fast neutron and gamma ray detectors can be used in a variety of applications to include the passive and active detection of SNM. For active applications, the detectors will be integrated with either neutron or high-energy gamma ray sources in order to either detect penetrating radiation or radiation resulting from fission. Fast neutron and gamma detectors would have relevance in the medical and other commercial industries for use in tomography and radiography applications.

REFERENCES: 1. Smith, M.B., H.R. Andrews, E.T.H. Clifford, H. Ing, V.T. Koslowsky, R.T. Noulty, M. Zhang, L.G.I. Bennett, M.L. Boudreau, A.R. Green, B.J. Lewis, R. Nolte, and S. Röttger. Canadian High-Energy Neutron Spectrometry System (CHENSS). International Workshop on Fast Neutron Detectors and Applications, 3 Apr. 2006. 8 Aug. 2006 <http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=25#session-1>.

2. Glasstone, Samuel, and Philip J. Dolan. United States of America. Department of Defense. The Effects of Nuclear Weapons. Washington, DC: US Government Printing Office, 1977.

3. Knoll, Glenn F. Radiation Detection and Measurement. 3rd ed. New York: John Wiley & Sons, Inc., 2000.

4. Bücherl, Thomas, and Christoph Lierse von Gostomski. Radiography Using Fission Neutrons. International Workshop on Fast Neutron Detectors and Applications, 3 Apr. 2006. 8 Aug. 2006 <http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=25#session-1>.

KEYWORDS: Radiation Detection, Semiconductors, High Voltage Bias, Charge Collection, Gamma Ray Spectrometry

DTRA07-002 TITLE: Real-Time Portable Neutron Spectroscopy

TECHNOLOGY AREAS: Nuclear Technology

OBJECTIVE: Development of a deployable neutron spectrometer for the prompt identification of materials by exploiting both spontaneous and stimulated neutron emissions.

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) seeks the means for extending the identification of materials to neutron spectroscopy for field applications. This solicitation seeks innovative approaches to achieve this capability in support of the DOD effort in countering terrorism, counter-proliferation and non-proliferation. Neutrons are notoriously difficult to shield and/or mask and could potentially serve as a preferred method to detect and identify fissile and special nuclear materials (SNM). However, neutron detection has traditionally been conducted using sensors which are of little benefit in an adverse environment being unwieldy, fragile, and providing little or no information about neutron energy. This solicitation will support the development of a portable neutron spectroscopy instrument capable of performing real time analysis of the data. The successful candidate sensor technology will be sufficiently rugged, lightweight and easy to use so that it may be operated effectively in typical DoD mission environments. The minimum energy resolution of this instrument will allow discrimination between neutrons emitted from fissile and other man-made radiological materials and neutrons to include background neutrons from cosmogenic sources. The time resolution shall also allow for a clear discrimination of prompt and delayed neutrons from nuclei undergoing fission.

PHASE I: Develop the conceptual design of a neutron sensor that:
o Can perform neutron spectroscopy with the energy resolution necessary to discriminate between fissile and other neutron emitting materials
o Can perform clear time discrimination between prompt and delayed neutrons.
o Weighs no more than 30 lbs
o Can be battery operated for up to 8 hours
Perform laboratory testing of any critical items.

PHASE II: Manufacture a prototype device which can be evaluated in a laboratory environment. Compare the performance of the neutron spectrometer against existing standards.

PHASE III DUAL USE APPLICATIONS: While the DoD requirement for field ruggedness and adverse operating environments is unique, neutron spectroscopy is relevant to both medical and industrial applications. Examples of medical applications of neutron spectrometers are, when used in conjunction with a neutron source, uses in study of soft material containing water and fast neutron therapy. Commercial applications include neutron radiography of structures.

REFERENCES: 1. Ambrosi, R.M., Watterson, J.I.W., et al. Characterisation of a large flat panel amorphous silicon detector for fast neutron and x-ray radiography, Presented at the Fifth Position Sensitive Detector Conference, PSD5, University College, London, 13-17 September 1999

2. Eberhardt, J.E., Rainey, S., Stevens, R.J., Sowerby, B.D., Tickner, J.R., Applied Radiation and Isotopes, Aug 2005

3. Kawabata, Y., Hino, M., Nakano, T., Sunohara, H., Matsushima, U., Geltenbort, P., Nuclear Inst. and Methods in Physics Research, A, Apr 2005

4. Knoll, Glenn F. Radiation Detection and Measurement. 3rd ed. New York: John Wiley & Sons, Inc., 2000.

5. Lindsay, J.T., Jones, J.D., Caveman, C.W., Real-Time Neutron Radiography and Its Application to the Study of Internal Combustion Engines and Fluid Flow, World Conference, June 1986.

6. Neutron Detection and Radiography Using Microsphere Plates, Isotopes and Radiation: Nuclear Analytical Techniques. Transactions of the American Nuclear Society 2001.

7. Overley, J.C. Element sensitive computed tomography with fast neutrons, Journal of Computer Assisted Tomography, vol. 7, no. 1, 1983, pp. 117-125

8. Ryzhov, I.V., Tutin, G.A., Mitryukhin, A.G., Soloviev, S.M., Blomgren, J., Renberg,P.-U., Meulders, J.-P., Masri, Y. El, Keutgen, Th., Preels, R., Nolte, R., Measurement of neutron-induced fission cross sections of 205Tl, 204;206;207;207Pb and 209Bi with a multi-section Frisch-gridded ionization chamber, accepted for publication in Nucl. Instr. Meth.

9. Von der Hardt, Peter and Röttger, Hans (editors) Neutron Radiography Handbook: An up-to-date Reference on Euratom's Radiography Working Group, Springer, 1989

KEYWORDS: Radiation Detection, Neutron Detection, Neutron Spectroscopy, Spontaneous Fission, Delayed Neutrons, Prompt Neutrons

DTRA07-003 TITLE: <u>Active Interrogation for Special Nuclear Materials (SNM) Detection</u>

TECHNOLOGY AREAS: Nuclear Technology

OBJECTIVE: To extend the stand-off range for detection of SNM, particularly when heavily shielded, using energetic neutral beams for interrogation.

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) seeks means of extending the standoff distance between detectors and SNM sources, particularly when heavily shielded or otherwise obscured by masking radioisotopes. Passive nuclear detection techniques of weak radionuclides are limited to a few meters distance and their effectiveness is further reduced by shielding. This solicitation seeks research into stronger, more directional beams of neutral energetic particles, either neutrons or gamma rays, for use in a field environment. This research also seeks to combine active beams with detection elements for identifying SNM in the presence of the induced radiation background from an active particle flux. The long-term goal of this research is to place a greater fluence of energetic species on a suspect target thereby increasing the distance at which an induced signal could be detected and positive identification made.

Current capability exists in small isotropic neutron sources, large directional neutron sources, large multi-spectral photonic sources, and mono-energetic gamma sources for radiography. Detector capability exists for the passive detection of gammas and neutrons. However, there is no capability for a portable/transportable active interrogation system that combines the individual technological elements into a fully capable detection system for use in a field environment. Imaging capability of a suspect target based on the detection of transmitted, scattered, and induced radiations is a desirable capability.

PHASE I: Develop a conceptual design for an active interrogation system and show the feasibility of using such a system for a DoD mission such as wide-area search for significant quantities of SNM (e.g., one kilogram) being transported in a ground vehicle.

PHASE II: Develop a prototype system operable in a field environment. Demonstrate with a laboratory test.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, highly directional beams of neutrons or gamma rays would have relevance in the medical industry. Commercial applications would also include radiography of structures for water intrusion. However, the DoD requirement for field ruggedness and adverse operating environments is unique among these applications.

REFERENCES: 1. Bücherl, Thomas, and Christoph Lierse von Gostomski. Radiography Using Fission Neutrons. International Workshop on Fast Neutron Detectors and Applications, 3 Apr. 2006. 8 Aug. 2006 <http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=25#session-1>.

2. Smith, M.B., H.R. Andrews, E.T.H. Clifford, H. Ing, V.T. Koslowsky, R.T. Noulty, M. Zhang, L.G.I. Bennett, M.L. Boudreau, A.R. Green, B.J. Lewis, R. Nolte, and S. Röttger. Canadian High-Energy Neutron Spectrometry System (CHENSS). International Workshop on Fast Neutron Detectors and Applications, 3 Apr. 2006. 8 Aug. 2006 <http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=25#session-1>.

KEYWORDS: Radiation detection, neutron sources, photo fission, prompt and delayed neutrons, prompt and delayed gammas

DTRA07-004 TITLE: Improvements in Scintillation Technology for Detection of Nuclear Radiation

TECHNOLOGY AREAS: Sensors, Nuclear Technology

OBJECTIVE: Develop innovative scintillator materials for the detection of gamma-ray or neutron radiation for a variety of applications. For handheld and arrayed detectors criteria for improvement include better energy resolution; higher light output (photons per MeV); improved linearity of light output; and smaller, more efficient and more rugged light readout technology to replace photomultiplier tubes and lower power consumption. For applications requiring detectors with very large volume, a low-cost material with significantly better energy resolution is required to replace plastic scintillators.

DESCRIPTION: Scintillators that exceed lanthanum halides in brightness with energy resolution approaching the statistical limits for scintillator-based gamma-ray spectrometry are needed for a variety of applications that include handheld detectors and imaging arrays. The goal of this SBIR is to investigate the next-generation scintillators that will exceed the lanthanum halides in brightness (>90,000 photons/MeV) yet have adequate linear response to gamma-ray energies from 60 keV to 3 MeV. These new scintillators should also provide energy resolution of <= 2% (FWHM) at 662 keV. Photomultiplier tubes (PMT) currently utilized for light collection and amplification are based on vacuum tube technology requiring a high-voltage bias for operation and relatively high power consumption. In high mechanical stress environments typically encountered by the US military in field environments, these devices can fail. PMTs may also be too bulky to use in imaging detectors based on scintillator arrays. Another goal of this SBIR is to investigate reliability and performance improvements in scintillator light collection (SLC) technology and to match improved SLC technology with the next-generation scintillator materials. For example, photodiodes that can be fabricated with CMOS technology and that operate in avalanche mode are a promising technology. Gamma-ray energy resolution in low-cost, large-volume scintillators of <10% (FWHM) at 662 keV would be a significant improvement over currently available plastic scintillators. Promising technologies for large-volume scintillators include ceramic and composite scintillators consisting of granular scintillating material in an appropriate binder. Scintillator materials with sensitivity to neutron radiation are needed, but responses to neutrons must be clearly distinguishable from responses to gamma rays even in intense radiation fields. Because of their generally fast response and recovery times, scintillator detectors have potential application in pulsed active interrogation systems for location and identification of special nuclear materials.

PHASE I: Develop new scintillator material(s) potentially useful for applications of interest to DTRA as identified above. Evaluate scintillation and electronic properties through laboratory measurements. Develop conceptual designs for matching SLC technology with the scintillator material and evaluate feasibility through laboratory testing of devices and components. Consider how the improved scintillating material might be produced in commercial-scale quantities.

PHASE II: Develop a prototype scintillator detector incorporating new materials as described above and/or employing improved SLC technology. Demonstrate in a laboratory test and comparison with present scintillation detectors (e.g., NaI and La halide) employing PMTs.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, improved scintillator detector technology would have relevance in the medical industry for gamma cameras, positron emission tomography, in-vitro assay, immunoassays, and liquid scintillation counters. Further, non-medical applications could be advanced biotechnology (such as DNA sequencers), high energy physics experiments, oil well logging, mass spectrometry, environmental measurements, color scanners, space imaging, and low-level light detection. Homeland Security applications include deployment of radiation detectors at fixed locations and at close standoff distances. However, the DoD requirement for field ruggedness and adverse operating environments is unique among these applications.

REFERENCES: 1. Glenn Knoll, Radiation Detection and Measurement, 3rd Edition, New York: John Wiley and Son, 2000.

2. Radiation Detection Symposium, University of Michigan, 22-26 May 2006, sponsored by DTRA.

KEYWORDS: Radiation Detection, Photo Multiplier Tube, High Voltage Bias, Photon Detection, Scintillator, Scintillation, Avalanche Photodiode

DTRA07-005 TITLE: The Characterization and Mitigation of Single Event Effects in Ultra-Deep Submicron (< 90nm) Microelectronics

TECHNOLOGY AREAS: Sensors, Electronics, Nuclear Technology

OBJECTIVE: The objectives of this task are to:
1. Characterization of Single-Event Effects in ultra-deep submicron (< 90nm) integrated circuits and
2. Development and demonstration of minimally invasive methods to mitigate SEE in ultra-deep submicron digital and analog/mixed-signal integrated circuits.

The successful outcome of this task will support the use of ultra-deep submicron integrated circuits in DoD satellite systems that will result in very significant savings in weight, power and reliability for systems that include Space Radar, Space Tracking and Surveillance Systems, TSAT and others. Each new generation of microelectronics results in performance benefits that include > 2X in integration density, > 4X in power savings and > 2X in operating speed making possible very significant improvements in system capabilities.

DESCRIPTION: Currently satellite systems are fabricated using a mix of commercial and radiation hardened circuits. However, the use of advanced commercial integrated circuits devices results in added complexity to mitigate SEE that can result in the mal-operation and/or destruction of devices. In many cases, the penalties in increased power, area, weight and added circuit complexity out-weigh any potential benefits and preclude the use of the advanced commercial technology.

Additionally, present methods to mitigate SEE while proven to be effective at circuits geometries > 150nm have been not proven to be adequate at integrated circuit feature sizes below 100nm.

Thus, if minimally invasive methods such as the use of alternative materials, circuit enhancements, and other innovative approaches could be developed to reduce SEE sensitivity these devices could be used with little or no penalties.

Therefore, the basic approach to accomplish this task would be to leverage commercial microelectronics at the < 90nm nodes and augment these technologies with SEE mitigation techniques that would have minimal impact on the electrical performance and manufacturability.

Additionally, the development of such methods requires the development of cost effective methods to model and simulate the SEE response of these < 90nm technologies. Without a robust modeling and simulation capability it would be both technically and economically unfeasible to develop these mitigation methods.

PHASE I:
• Identification of minimally invasive methods, including material approaches, to mitigate SEE in < 90nm microelectronics technologies including III-V and SiGe materials systems.

• Development of cost effective SEE modeling and simulation methods for < 90nm microelectronics digital and analog/mixed-signal microelectronics.

PHASE II:
• Electronic Design Automation tools (programs) that can;
  o Identify design sensitivities in complex integrated circuits
  o Design radiation insensitive integrated circuits
  o Perform trade studies to provide optimized integrated circuits WRT radiation and electrical performance
  o Analysis the radiation response of complex integrated circuits

• Technology Computer Aided Design (TCAD) tools that can:
  o Provide cost effective 3-D models to support the simulation of the radiation response of nanotechnology microelectronics.
  o Identify radiation sensitivities at the transistor level

• Mixed-Mode and Level Simulation systems that can effectively couple the radiation response at the transistor level to higher levels of circuit and subsystem integration (e.g. transistor response to small circuit to complex circuit to sub-system) to support the accurate radiation response simulation up to and including the sub-system level.

• Radiation effects Product Design Kits (PDK) that combine the electrical and radiation response design and modeling parameters for a specific technology. PDKs are provided by semiconductor manufacturers to their customers to support design activities. In general a semiconductor manufacturer will develop an electrical performance and design PDK that must be then augmented with radiation performance to support customer s that require the technology to be used in a radiation environment.

• Development and demonstration of < 90nm SEE modeling and simulation methods

PHASE III DUAL USE APPLICATIONS: Use of the mitigation, modeling and simulation methods developed through this effort to support the use of advanced microelectronics for terrestrial application such a very high performance microprocessor, advanced Servers, and very large cache memories.

REFERENCES: 1. IEEE Transactions on Nuclear Science; December 2005, Volume 52, Number 6, Session A Single Even Effects: Mechanisms and Modeling, pages 2104-2231

2. IEEE Transactions on Nuclear Science; December 2005, Volume 52, Number 6, Session F Single Even Effects: Devices and Integrated Circuits, pages 2421-2495

3. JEDEC 57, SEE Test and Characterization Guidelines and Test Method

KEYWORDS: Single-Event Effects, Single-Event Upset, Single-Event Transients

DTRA07-006 TITLE: Hardening Electronics to Electromagnetic Threats

TECHNOLOGY AREAS: Sensors, Nuclear Technology

OBJECTIVE: New low-cost technologies for hardening electronic systems against electromagnetic threats from the various forms of electromagnetic pulse sources, including different emissions from high power microwave (HPM) sources. The technologies to be developed are required to address electromagnetic standards and specifications provided, for example, in the references given below.

DESCRIPTION: Electromagnetic threats (HPM and EMP) pose significant problems to electronics both as conducted (e.g., on wires and antennas) and radiated (e.g., through apertures and cracks) energy. A variety of techniques for various frequency bands have been developed over the past 30 years to protect electronics from these threats. These techniques, however, are frequently costly to implement and have size limitations. The desire is to develop innovative, new technologies/techniques that are lower-cost and compact. The "EM Pro Cord" (data sheet available from Fischer Custom Communications, Inc., 20603 Earl Street, Torrance, CA 90503) is an example of such previously developed capability. Further, it is desirable that the techniques be applicable over a broad frequency range for individual conducted or radiated threats, and for both EMP and HPM. In the area of nuclear EMP, conductive protection devices are desired that cover the early time (E1), mid time (E2), and late time (E3) threat environments via one compact unit. For HPM, methods to protect the electronics directly (similar to radiation hardening electronics) would be of great interest. Feasibility is based upon success in other electronic technologies of this complexity.

PHASE I: Proof of concept should be demonstrated by analysis and/or preliminary experimental device. A detailed plan for further engineering development and for demonstration testing during Phase 2 should also be provided.

PHASE II: Successfully demonstrate the operation of the prototype hardening device against specified electromagnetic threat(s) without damage to the protection device or protected circuit.

PHASE III: Demonstration of EMP and HPM protection devices to meet MIL-STD 188-125 and other applicable military and commercial standards should encourage various DoD program offices to support further development of the technology. Dual use of devices for protection of both military systems and commercial facilities/civilian infrastructures from potential terrorist threats is a plus.

REFERENCES: 1. HEMP Hardening of C4I Facilities, Volume 1 – Fixed Facilities, MIL-STD-188-125-1.

2. HEMP Hardening of C4I Facilities, Volume 2 – Transportable Facilities, MIL-STD-188-125-2.

3. HEMP Protection of Time-Critical C4I Facilities, MIL-HDBK-423.

4. System E3 Requirements, MIL-STD-464A, 19 December 2002.

5. EMI Emissions/Susceptibility, MIL-STD-461E, 20 August 1999.

KEYWORDS: High-power microwave, EMP, electromagnetic pulse, protection, electromagnetic, hardening

DTRA07-007 TITLE: Sensor for Electromagnetic Threats

TECHNOLOGY AREAS: Sensors, Nuclear Technology

OBJECTIVE: New low-cost technologies for sensing electromagnetic threats from different emissions of high power microwave (HPM) sources.

DESCRIPTION: Electromagnetic threats pose significant problems to electronics; and it is important in operation of military and critical civilian systems to determine when the systems are being irradiated. An innovative electromagnetic (EM) warning sensor is desired that can alert system operators of undesired intense EM radiation on their systems. The sensor is expected to operate primarily for high-power microwave with a low false alarm rate. It is important to be able to handle different emissions (e.g., frequency, intensity) that are possible. A network of several sensor elements and a variable alarm threshold may be required to reduce false alarms.

While the nuclear EMP threat signal has been specified (examples can be found in IEC 6100-2-9 and MIL-STD-464), the HPM threat signal is not as well characterized. It can be assumed, however, to include approximately 100-ns to 1-microsecond pulses in the frequency range of 0.5 – 3 GHz. It may or may not be repetitive. Project involves a moderate-to-high degree of technical risk due to the wide variation in EM signal possible and the hazard a particular presents to wide variety of systems. Feasibility of the technology to be developed is based upon success in other microwave applications of this complexity.

The objective HPM sensor should be capable of identifying time(s) of attack and frequency of attack. It should also be small/compact, require low operating power and provide a level and excursion audible signals as outputs indicating presence of an EM threat. The sensor should be capable of surviving exposure to 5 W/cm2 for HPM.

PHASE I: Proof of concept should be demonstrated by analysis and/or preliminary experimental device. A detailed plan for further engineering development and for demonstration testing during Phase 2 should also be provided.

PHASE II: Successfully demonstrate the operation of the prototype EM sensor to warn against electromagnetic threats.

PHASE III: Demonstration of EM sensor should encourage various system program offices to consider inclusion of sensor into their systems that have a specification to operate in EM threat environment. Dual use of EM sensor for warning of EM exposure from potential terrorist threats to both military systems and commercial facilities/civilian infrastructures is a plus. Such a sensor could have important application to civilian aircraft and key civilian computer installations, to include supervisory control and data acquisition (SCADA) systems.

REFERENCES: 1. "Personal Microwave Dosimeter," data sheet Model 5000830, Market Central, Inc., 500 Business Center Drive, Pittsburg, PA 15205.

2. References under "Microwave Detection" and "Microwave Detectors" on Worldwide Web (e.g., www.microwaves101.com).

KEYWORDS: High-power microwave, sensor, electromagnetic, HPM

DTRA07-008 TITLE: Development of Bridge Damage Evaluation Methodology for Bombing

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Develop a methodology for assessing bridge vulnerability related to various bomb damage scenarios. Identify important characteristics of typical bridges related to bomb damage and establish the feasibility of the proposed analysis methodology, which will employ a damage index to assess the vulnerability of a bridge. Establish sample resistance functions for bridges that reflect the blast damage.

DESCRIPTION: For the shape and load resistance mechanism, bridge structures have different structural characteristics and functions from typical components of buildings. Most of the internal energy should be concentrated into several primary components such as girders and boxes according to the type of bridges. Though there have been lots of trials to distribute the resistance role to the secondary components, i.e., cables, trusses and combinations of several components, still most of the internal energy should be resisted by primary member. However, the bridge structures cannot stand if the primary component fails completely.
The decision should be made in case of partial damage of the primary or very important secondary components. The damage should be assessed on the basis of the bridge design concept, which is far different from the building for its functional purpose – transportation.
Damage mechanisms for various types of bridges should be reviewed and the bridge types of most interest selected. The effect of blast loads on the capacity of a bridge to carry the design loads should be evaluated. Conventional and advanced dynamics analysis methods should be considered. Appropriate procedures should be established for determining the effects of blast damage.

PHASE I: Conduct detailed high-performance computing analytical study of the response and failure mechanisms of key bridge components to contact- and near-contact detonations. Key bridge components requiring further study include: steel and reinforced/prestressed concrete box structures (including suspension and cable-stayed towers, arch ribs, box girders, etc.); steel truss elements; small- and large-diameter steel cables; steel and reinforced/prestressed girders; steel and reinforced concrete pier columns of varied dimensions.

PHASE II: Conduct explosive tests against scaled models of these components for validation of the computational efforts. Such tests are required because these components are quite unique to bridges and most of the testing in the past has been on building components and most importantly, very little analytical validation has been accomplished in the “contact- to near-contact” detonation regime, which is also a problem that bridge structures uniquely face; i.e. standoff is not an option on bridge structures.

PHASE III DUAL USE APPLICATIONS: Develop fast-running analytical models (specifically, a set of weapon size vs. standoff curves) for these key components. Conduct a detailed analytical study of progressive collapse issues for complex bridge structures. Develop and test mitigation measures for key bridge components (listed above) exposed to contact- and near-contact detonations. Commercialize engineering aids/software products for use in the architecture, engineering, and construction industries.

REFERENCES: 1. H. Choi, "Consideration on Bridge Blast Analysis and its Damage Evaluation", The 76th Shock & Vibration Symposium, October 30 – November 3, 2005, Destin, FL.

2. "Blast Testing and Research – Bridge at the Tenza Viaduct", University of Missouri-Rolla, TSWG Contract Number N4175-05-R-4828, Final Report of Task 1, 2005.

3. "A Review of Structural Health Monitoring Literature: 1996-2001", Los Alamos National Laboratory Report, LA-13976-MS, 2003.

4. H. Choi, T. Krauthammer, "Determination of Effective Cable Stayed Bridge Link Pin Nondestructive Test", International Association for Bridge and Structure Engineering, Seoul, Korea, June 2001.

KEYWORDS: Bridge, Damage, Blast, Load Resistance, FRM, HFPB, Identification

DTRA07-009 TITLE: Cumulative Reinforced Concrete (RC) Damage Identification and Residual Strength Capacity Prediction due to Blast and Fragment Loadings

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

OBJECTIVE: Find a reliable and inexpensive way to define RC component damage due to multiple loading events. Develop appropriate engineering aids / software defining structural capacity due to incremental abnormal loadings events (e.g., multiple air strikes).

DESCRIPTION: DoD needs to develop the ability to efficiently and effectively assess damage and evaluate the residual strength (structural capacity) of concrete or other geomaterial structural components to airblast, fragments, and munition penetrations. Currently, damage predictions require a baseline assessment of vulnerability at a pristine state and an a priori understanding of the localized damage evolution and prevalent boundary conditions of the structure at each incremental loading stage, such as occurs in a multistrike event. A multistrike event is defined as a repeated abnormal loading of structures or its components. A continuous definition of the residual capacity of damaged components and structures is extremely important for weaponeering hardened targets, and could be exceptionally helpful in remote or close by battle damage assessments (BDA), planning protection from sequenced terrorist attacks, or follow on abnormal loads such as extreme wind and hurricane conditions. Building Health Monitoring (HM) and other remote sensing technologies cross correlated to finite element models of an intact or known state of the component or structure have had limited success. To discriminate damage, often these methodologies rely upon extensive engineering judgments and statistical models to distinguish local anomalies, loading variability and errors associated with modeling and simulation. A new technology is needed to:
1. Remotely acquire (often an incomplete) data and through lasers, clutterless imagery, or other means (e.g., fired in penetrating sensors) assess state of structural residual capacity and / or existing state of stability.
2. Through algorithms convert acquired information to pertinent engineering level aids (e.g. P-I curves) / software describing evolutionary damage and residual component strength / structural capacity.

PHASE I: Design / identify concepts for remote and progressive sensing. Provide pertinent basis for defining damage / capacity of component / structure independent of continuous testing or analyses and not on condition of previous structural / material evolution states.

PHASE II: Develop an end to end methodology / techniques and hardware for evaluating damage and pertinent engineering level aids (e.g. P-I curves) / software describing evolutionary damage and residual strength / structural capacity due to multiple abnormal events and disassociated of continuous testing or analyses.

PHASE III DUAL USE APPLICATIONS: Provide a new generation of HM systems with a wider applicability to structures lacking a baseline estimate. Commercialize HM technology and engineering aids / software products for use in the architecture, engineering and construction industries

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KEYWORDS: Multistrike, sensors, concrete, damage, residual strength, abnormal loading, HM, remote

DTRA07-010 TITLE: <u>Measuring Residual Concrete Strength After Penetration and Blast</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Find a reliable inexpensive way to measure resistance to penetration (for subsequent weapons) in damaged concrete.

DESCRIPTION: When munitions are used in multiple strikes against reinforced concrete slabs (for example, burster slabs over cut and cover targets with concrete layers), if the first weapon does not penetrate all the way to the target room, it is important to know the remaining strength of the damaged slabs. For subsequent strikes, the remaining strength determines the time for penetration to the target room, from which the fuze setting must be determined. In the test environment, current methods of measuring residual strength include coring the slab and measuring compressive strength, and shooting instrumented penetrators through the slab, observing acceleration, and backing in the strength by running trial and error simulations. The first method can not be used when the slab is heavily damaged, as frequently occurs. The second method costs $10,000 per data point and is time consuming.

PHASE I: Identify concept. Design a device (and methodology) perhaps used for direct, but preferably remote, measurement. The device shall have the ability to measure, or predict based on measured damage, a damaged slab's remaining ability to subtract kinetic energy from subsequent penetration at location (x,y). The device shall use the remaining strength measurement at (x,y) to predict the time elapsed from impact until a penetrator tail exits the damaged concrete slab and the exit velocity. In subsequent penetrations, the device (perhaps a second device) shall measure the actual exit velocity and elapsed time. Impact velocities are on the order of 1 foot per millisecond. The 90% confidence interval width for measuring or predicting penetrator tail exit velocity from a damaged concrete slab shall be near 1/2 foot per millisecond. It is acceptable to predict (or measure) the velocity and time of arrival at depth d (in soil) below the slab. It is acceptable to specify (x,y) coordinates of subsequent penetrations prior to the test.

PHASE II: Prototype development. Build the device, and confirm it meets the accuracy specified above. Use designed experimentation, collect data by blowing up slabs of varying strength and thickness and measuring residual strength using the device from Phase I. Predict penetrator tail exit time and velocity. Perform confirmation penetration shots.

PHASE III DUAL USE APPLICATIONS: (1) The device might be used to measure the remaining strength of concrete walls damaged by terrorist bombs. (2) Given the confirmation data, slab attributes can be determined so as to minimize damage. This might allow specification of construction parameters to resist damage. (3) This may have use in evaluating hypervelocity penetration.

REFERENCES: 1. Adley, M.D., Berger, R.P., and Creighton, D. C. (1994). "Two-Dimensional Projectile Penetration Into Curvilinear Geologic/Structural Targets: User's Guide for PENCURV-PC," V1.5, Instruction Report SL-94-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

2. Curry, T.F., and E.J. Jerome, Discriminant Analysis Models for Unified Damage Prediction Across Failure Modes, Journal of the International Test and Evaluation Association, Vol. 23. No. 4 (December 2002, January 2003).

KEYWORDS: Concrete, blast, penetration, strength, damage

DTRA07-011 TITLE: Novel Methods to Measure Penetrator Dynamics in Multi-Layer Geometries

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

OBJECTIVE: DTRA requires the capability to understand the dynamics of a projectile as it penetrates through multi-layers of various materials to understand the effects of terradynamics and the overall vector velocity of the projectile.

DESCRIPTION: Ultra-sonic sensors within a penetrating weapon may be able to provide information into the material properties of the geology/material being penetrated. Measurement techniques that can be used within the projectile to record, in-situ or transmitted data, will greatly increase the understanding of the projectile performance. Transmittable data can be used with Battle Damage Investigation (BDI) technologies. In analogous applications, acoustic emissions are used in geotechnical cone penetrometer sounding techniques. Having similar sensors on the penetrating weapon would help us understand the projectile's depth of penetration and ability to sense a change in layer material which is of interest to DTRA for potential fuze technology.

PHASE I: Develop measurement design capable of meeting objective.

PHASE II: Develop and demonstrate a prototype system and conduct testing on ongoing DTRA MOP test program.

PHASE III DUAL USE APPLICATIONS: The measurement technique has a variety of military and commercial applications in BDI and in further research and development efforts of projectile penetration physics. We anticipate significant applications in the geotechnical site characterization area. Acoustic sensors are used by civil engineering community to monitor bridges and dams.

REFERENCES: 1. Huang, et. al, Using Acoustic Emission in Fatigue and Fracture Materials Research, JOM-e, November 1998 (vol. 50, no. 11), http://www.tms.org/pubs/journals/JOM/9811/Huang/Huang-9811.html

KEYWORDS: FUZE, Smart Fuze, Terradynamics, Penetrator

DTRA07-012 TITLE: Biological Simulant Collection and Analysis in an Explosive Environment

TECHNOLOGY AREAS: Chemical/Bio Defense, Weapons

OBJECTIVE: Establish approaches and develop a full-scale testing diagnostic capability that will enable the tester to simultaneously locate and quantify live/biologically active simulant for various biological warfare agents released in near-real time, and within the explosive environment created as the result of a test employing an Agent Defeat weapon against a target containing these agents.

DESCRIPTION: One of the major challenges to developing, modeling, and evaluating the performance of Agent Defeat Weapons is the current inability to quantify with any level of certainty the quantity of "untouched" biological simulant that was released (if any) from the test facility as a result of the test event. Several methods exist for measuring with some degree of accuracy and precision in the far field, outside the environment created by the explosive event. This approach suffers in the ability to collect a statistically relevant sample of the released plume, both in the spatial and time dependent fields, in order to evaluate the weapon's performance. In addition, the samplers utilized for the far field approach have been shown to lack the survivability required in the near field. Collecting samples of the released plume in the near field provides for a statistically relevant data set, measurements and associated mass release analysis, and ensures better control of the variables associated with analyzing and modeling the performance of an Agent Defeat Weapon. Innovative and novel concepts are desired for collecting, identifying, and quantifying, in near real time, the types and amounts biological simulant present in the near field during a full-scale Agent Defeat Weapons test event at a given target.

PHASE I: Concept a study with preliminary data included for the development of a biological agent diagnostic capability potentially suitable and survivable for use in the full-scale Agent Defeat Weapon testing environment:
- Temperature Environments on the order of 1500 degrees Celsius
- Pressure Environments on the order of 2000 psi
- Velocity Environment on the order of 300 m/s
- Acidic and Caustic Environments: pH 3–10

PHASE II: Using the results of Phase I, validate the biological diagnostic capability to provide qualitative and quantitative near-real time analysis across a broad spectrum of expected environments.

PHASE III DUAL USE APPLICATIONS: The outcomes of the investigation will have a wide variety of military and commercial applications in military and civil homeland security plume hazard analysis applications. Follow-on activities are expected to yield opportunities to apply this technology to commercial or other government uses. Homeland Security and state and local agencies may be possible applications.

REFERENCES: 1. "Defense Threat Reduction Agency, 2003 Strategic Plan", http://www.dtra.mil/about/media/brochures/index.cfm.

2. "National Military Strategy to Combat Weapons of Mass Destruction (NMS-CWMD)", February 2006; http://www.defenselink.mil/pdf/NMS-CWMD2006.pdf

KEYWORDS: Agent Defeat, Test and Diagnostics, Biological Detection, Biological Simulant, Biological Assays